

WHAT IS CLAIMED IS:

1. A method of forming a multi-layer dielectric structure, the method comprising:  
forming a first dielectric layer on a substrate according to a CVD process; and  
forming a second dielectric layer directly on the first dielectric layer according  
5 to an ALD process.
2. The method according to Claim 1, wherein the first dielectric layer  
comprises one selected from the group consisting of SiO<sub>2</sub>, Si<sub>3</sub>N<sub>3</sub>, Ta<sub>2</sub>O<sub>5</sub>, HfO<sub>2</sub>, ZrO<sub>2</sub>,  
TiO<sub>2</sub>, Y<sub>2</sub>O<sub>3</sub>, Pr<sub>2</sub>O<sub>3</sub>, La<sub>2</sub>O<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub>, SrTiO<sub>3</sub> (STO), BaSrTiO<sub>3</sub> (BST) and PbZrTiO<sub>3</sub>  
10 (PZT).
3. The method according to Claim 1, wherein the second dielectric layer  
comprises one selected from the group consisting of SiO<sub>2</sub>, Si<sub>3</sub>N<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>, Ta<sub>2</sub>O<sub>5</sub>, HfO<sub>2</sub>,  
ZrO<sub>2</sub>, TiO<sub>2</sub>, Y<sub>2</sub>O<sub>3</sub>, Pr<sub>2</sub>O<sub>3</sub>, La<sub>2</sub>O<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub>, SrTiO<sub>3</sub> (STO), BaSrTiO<sub>3</sub> (BST) and PbZrTiO<sub>3</sub>  
15 (PZT).
4. The method according to Claim 1, wherein the first dielectric layer  
includes HfO<sub>2</sub> and the second dielectric layer includes Al<sub>2</sub>O<sub>3</sub>.
- 20 5. The method according to Claim 1, wherein forming a first dielectric  
layer comprises forming the first dielectric layer at a temperature in a range from  
about 25°C to about 700°C and a pressure in a range from about  $1 \times 10^{-6}$  Torr to about  
760 Torr during the CVD process, and wherein forming a second dielectric layer  
comprises forming the second dielectric layer at a temperature in a range from about  
25 25°C to about 700°C and a pressure in a range from about  $1 \times 10^{-6}$  Torr to about 760  
Torr during the ALD process.
6. A method of forming a multi-layer dielectric structure, the method  
comprising:  
30 forming a first dielectric layer on a substrate according to an ALD process;  
and

forming a second dielectric layer directly on the first dielectric layer according to a CVD process.

7. The method according to Claim 6, wherein the first dielectric layer  
5 comprises one selected from the group consisting of SiO<sub>2</sub>, Si<sub>3</sub>N<sub>3</sub>, Ta<sub>2</sub>O<sub>5</sub>, HfO<sub>2</sub>, ZrO<sub>2</sub>, TiO<sub>2</sub>, Y<sub>2</sub>O<sub>3</sub>, Pr<sub>2</sub>O<sub>3</sub>, La<sub>2</sub>O<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub>, SrTiO<sub>3</sub> (STO), BaSrTiO<sub>3</sub> (BST) and PbZrTiO<sub>3</sub> (PZT).

8. The method according to Claim 6, wherein the second dielectric layer  
comprises one selected from the group consisting of SiO<sub>2</sub>, Si<sub>3</sub>N<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>, Ta<sub>2</sub>O<sub>5</sub>, HfO<sub>2</sub>,  
10 ZrO<sub>2</sub>, TiO<sub>2</sub>, Y<sub>2</sub>O<sub>3</sub>, Pr<sub>2</sub>O<sub>3</sub>, La<sub>2</sub>O<sub>3</sub>, Nb<sub>2</sub>O<sub>5</sub>, SrTiO<sub>3</sub> (STO), BaSrTiO<sub>3</sub> (BST) and PbZrTiO<sub>3</sub> (PZT).

9. The method according to Claim 6, wherein the first dielectric layer  
includes HfO<sub>2</sub> and the second dielectric layer includes Al<sub>2</sub>O<sub>3</sub>.  
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10. A method of forming an integrated circuit capacitor, the method  
comprising:  
forming a first electrode on a substrate;  
forming a first dielectric layer on the first electrode using a first one of an  
20 ALD process and a CVD process;  
forming a second dielectric layer on the first dielectric layer using a second  
one of the ALD process and the CVD process; and  
forming a second electrode on the second dielectric layer.

25 11. The method according to Claim 10, wherein forming a first dielectric  
layer comprises forming the first dielectric layer in a first chamber, and wherein  
forming a second dielectric layer comprises forming the second dielectric layer in a  
second chamber.

30 12. The method according to Claim 11, further comprising transferring the  
substrate after forming the first dielectric layer while maintaining a vacuum on the  
substrate.

13. The method according to Claim 12, wherein transferring the substrate after forming the first dielectric layer while maintaining a vacuum on the substrate comprises transferring the substrate via a transfer chamber configured to be selectively coupled to the first and second chambers.

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14. The method according to Claim 10:

wherein the first dielectric layer comprises one selected from the group consisting of  $\text{SiO}_2$ ,  $\text{Si}_3\text{N}_3$ ,  $\text{Ta}_2\text{O}_5$ ,  $\text{HfO}_2$ ,  $\text{ZrO}_2$ ,  $\text{TiO}_2$ ,  $\text{Y}_2\text{O}_3$ ,  $\text{Pr}_2\text{O}_3$ ,  $\text{La}_2\text{O}_3$ ,  $\text{Nb}_2\text{O}_5$ ,  $\text{SrTiO}_3$  (STO),  $\text{BaSrTiO}_3$  (BST) and  $\text{PbZrTiO}_3$  (PZT); and

10 wherein the second dielectric layer comprises one selected from the group consisting of  $\text{SiO}_2$ ,  $\text{Si}_3\text{N}_3$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{Ta}_2\text{O}_5$ ,  $\text{HfO}_2$ ,  $\text{ZrO}_2$ ,  $\text{TiO}_2$ ,  $\text{Y}_2\text{O}_3$ ,  $\text{Pr}_2\text{O}_3$ ,  $\text{La}_2\text{O}_3$ ,  $\text{Nb}_2\text{O}_5$ ,  $\text{SrTiO}_3$  (STO),  $\text{BaSrTiO}_3$  (BST) and  $\text{PbZrTiO}_3$  (PZT).

15. The method according to Claim 10:

15 wherein the first dielectric layer comprises one selected from the group consisting of  $\text{SiO}_2$ ,  $\text{Si}_3\text{N}_3$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{Ta}_2\text{O}_5$ ,  $\text{HfO}_2$ ,  $\text{ZrO}_2$ ,  $\text{TiO}_2$ ,  $\text{Y}_2\text{O}_3$ ,  $\text{Pr}_2\text{O}_3$ ,  $\text{La}_2\text{O}_3$ ,  $\text{Nb}_2\text{O}_5$ ,  $\text{SrTiO}_3$  (STO),  $\text{BaSrTiO}_3$  (BST) and  $\text{PbZrTiO}_3$  (PZT); and

wherein the second dielectric layer comprises one selected from the group consisting of  $\text{SiO}_2$ ,  $\text{Si}_3\text{N}_3$ ,  $\text{Ta}_2\text{O}_5$ ,  $\text{HfO}_2$ ,  $\text{ZrO}_2$ ,  $\text{TiO}_2$ ,  $\text{Y}_2\text{O}_3$ ,  $\text{Pr}_2\text{O}_3$ ,  $\text{La}_2\text{O}_3$ ,  $\text{Nb}_2\text{O}_5$ ,  $\text{SrTiO}_3$  (STO),  $\text{BaSrTiO}_3$  (BST) and  $\text{PbZrTiO}_3$  (PZT).

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16. An apparatus for forming multi-layer dielectric structures on a semiconductor substrate, the apparatus comprising:

25 a first chamber configured to form dielectric layers according to a chemical vapor deposition (CVD) process;

a second chamber configured to form dielectric layers according to an atomic layer deposition (ALD) process; and

means for providing a substrate to one of the first and second chambers for formation of a first dielectric layer on the substrate and for automatically transferring the substrate to a second one of the first and second chambers for formation of a second dielectric layer directly on the first dielectric layer.

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17. The apparatus according to Claim 16, wherein the means for providing the substrate to a first one of the first and second chambers for formation of a first

dielectric layer on the substrate and for automatically transferring the substrate to the second one of the first and second chambers for formation of a second dielectric layer on the first dielectric layer comprises means for transferring the substrate between the first and second chambers while maintaining a vacuum on the substrate.

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18. The apparatus according to Claim 17, wherein the means for transferring the substrate between the first and second chambers while maintaining a vacuum on the substrate comprises a transfer chamber configured to be selectively coupled to the first and second chambers.

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19. The apparatus according to Claim 18, further comprising:  
a loadlock chamber configured to vacuumize the transfer chamber; and  
a cooling chamber configured to maintain a temperature of the transfer chamber.

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20. The apparatus according to Claim 16:  
wherein the first chamber is configured to form dielectric layers of a material selected from the group consisting of  $\text{SiO}_2$ ,  $\text{Si}_3\text{N}_3$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{Ta}_2\text{O}_5$ ,  $\text{HfO}_2$ ,  $\text{ZrO}_2$ ,  $\text{TiO}_2$ ,  $\text{Y}_2\text{O}_3$ ,  $\text{Pr}_2\text{O}_3$ ,  $\text{La}_2\text{O}_3$ ,  $\text{Nb}_2\text{O}_5$ ,  $\text{SrTiO}_3$  (STO),  $\text{BaSrTiO}_3$  (BST) and  $\text{PbZrTiO}_3$  (PZT); and  
wherein the second chamber is configured to form dielectric layers of a material selected from the group consisting of  $\text{SiO}_2$ ,  $\text{Si}_3\text{N}_3$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{Ta}_2\text{O}_5$ ,  $\text{HfO}_2$ ,  $\text{ZrO}_2$ ,  $\text{TiO}_2$ ,  $\text{Y}_2\text{O}_3$ ,  $\text{Pr}_2\text{O}_3$ ,  $\text{La}_2\text{O}_3$ ,  $\text{Nb}_2\text{O}_5$ ,  $\text{SrTiO}_3$  (STO),  $\text{BaSrTiO}_3$  (BST) and  $\text{PbZrTiO}_3$  (PZT).